

Extruded Polystyrene Foam Insulation (XPS)

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EXTRUDED POLYSTYRENE FOAM ASSOCIATION

XPS Insulation

- R-5 per inch
- Common thickness
 - 1", 1 ½", 2", 3" (and 7/16", ½", ¾")
- Common sizes
 - 2'x8', 4'x8', 4'x9'
 - Square edge (most common), also T&G or shiplap edge
- Common uses
 - Above grade wall, exterior
 - Below grade wall, interior or exterior
 - Under concrete slab

Design & Construction with Thicker Foam Continuous Insulation - Resources

- Websites
 - XPS manufacturers: Dow, Owens Corning, Pactiv
- Design
 - Dow Builder's Guide
 - Owens Corning Builder's Guide
 - Building Science Corporation
 - Building America
- Fenestration installation
 - XPS mfg. builder guides, and fenestration manufacturer instructions
- Cladding attachment
 - Foam Sheathing Coalition "Tech Matters"

Dow Building Solutions Test Homes Research Project

**Project TEETH
Ten Energy Efficient Test Homes
Midland, Michigan**

Multi-home, 5 year research project
Dow Building Solutions partnership with Cobblestone Homes
Designed to meet latest energy code requirements
Determine builder costs to improve efficiency
Investigate performance of several building enclosure designs

All following slides courtesy Dow Building Solutions (Dow Chemical Co.)

Project TEETH Research Objectives

- Demonstrate ways to:
 - Lower the cost of home ownership
 - Improve home performance
- Produce real world data on:
 - Construction cost
 - Building materials purchased by builder through normal channels
 - Energy use
 - Wall durability performance
 - Occupant comfort and perception
- Create output useful in construction decisions

Experimental Design

Three Homes Built For Each Energy Efficiency Design

Baseline HERS 82	Meet 2006 IECC Typical Local Practices (Michigan)
2012 IECC Cavity Insulation Minimum cost HERS 57	Meet 2012 IECC Least Changes & Lowest Possible Price Point
2012 IECC Cavity plus Foam C. I. Premium Package HERS 57	Meet 2012 IECC Continuous Insulation & SPF
Beyond 2012 IECC Premium Package HERS – mid 40s	Beyond 2012 IECC Renewable Ready



Research Neighborhood

Midland, Michigan Climate Zone 5-6

2006 IECC



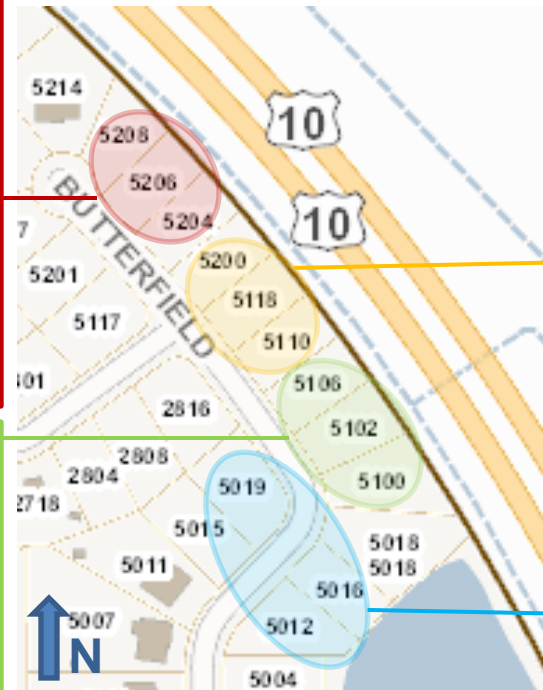
49-Kendall



48-Somerset



50-Preston



2012 IECC



51-Kendall



53-Preston



52-Somerset

2012 IECC CI



54-Preston



56-Kendall



55-Somerset

Beyond 2012 IECC



59-Preston



58-Somerset



62-Kendall

Above Grade Wall and Ceiling Design

	Cavity Insulation		Cavity Insulation w/ Foam Continuous Insulation	
	2006 IECC	2012 IECC	2012 IECC-CI	Beyond 2012 IECC
Stud Dimensions	2X6 16"o.c.	2X6 16"o.c.	2X4 16"o.c.	2X6 24"o.c.
Stud Cavity	R-19 FG batt	R-19 FG batt	R-16 cc SPF	R-31 cc SPF
Wall Exterior	OSB & Housewrap	OSB & Housewrap	R-5.5 SIS (structural insulating sheathing)	R-5.5 SIS + R-5 XPS
Ceiling	R-38 Dry Blown Cellulose	R-49 Dry Blown Cellulose	R-49 Dry Blown Cellulose	R-12 2"cc SPF & R-49 Dry Blown Cellulose

Windows and Mechanical Design

	Cavity Insulation		Cavity Insulation w/ Foam Continuous Insulation	
	2006 IECC	2012 IECC	2012 IECC-CI	Beyond 2012 IECC
Windows	U-.35	U-.32	U-.32	U-28
Furnace	80% AFUE	92% AFUE	92% AFUE	95% AFUE
AC	13 SEER	13 SEER	13 SEER	13 SEER
Water Heating	62% Electric	62% Electric	62% Electric	62% Electric
High Efficiency Lighting	0%	75%	75%	100%

Foundation & Floor Design

	Cavity Insulation		Cavity Insulation w/ Foam Continuous Insulation	
	2006 IECC	2012 IECC	2012 IECC -CI	Beyond 2012 IECC
Under Floor Slab	None	None	None	R-10 XPS
Rim Joist -Interior	R-19 FG batt	R-19 FG batt	R-16 cc SPF	R-16 cc SPF
Rim Joist – Exterior	None	None	R-5 XPS	R-10 XPS
Basement Wall – Interior Finished	R-13 FG batt	R-19 FG batt	R-5 XPS	R-10 XPS
Basement Wall - Interior Unfinished	R-10 FG vinyl faced	R-15 FG vinyl faced	R-5 PIR	R-10 PIR
Basement Wall – Exterior	None	None	R-10 XPS	R-10 XPS

Construction Cost Comparison

Actual Cost Complications

- Lot variations
- Elevation differences
- Material upgrades
- Weather related costs
- Price variations
 - ✓ Price fluctuations throughout the term of the project
 - ✓ Different suppliers or subcontractors
- Invoicing errors
- Quantity variations
 - ✓ Rob Peter to pay Paul
 - ✓ Different subcontractors
 - ✓ Theft
 - ✓ Damage

Isolating Energy Related Costs

- Exclude costs not related to energy levels
- Equalize all material and labor prices across the board
- Equalize or calibrate quantities
 - ✓ Use consistent areas between same house types
 - ✓ Use an actual material count across same house types
 - ❖ Make adjustments only when needed based on solid, logical and defensible judgments

Cost Summary

<i>Somerset Model - Ranch</i>	Framing, Insulation & Air Sealing	Windows & Exterior Doors	HVAC	Lighting	TOTAL	Premium from Baseline
2006 IECC	\$ 14,888	\$ 3,356	\$ 6,922	\$ -	\$ 25,166	
2012 IECC - Fiber	\$ 15,396	\$ 4,545	\$ 6,375	\$ 100	\$ 26,416	\$ 1,250.27
2012 CI Dow Premium	\$ 19,619	\$ 4,545	\$ 6,375	\$ 100	\$ 30,639	\$ 5,472.96
Beyond 2012 IECC - Renewable Ready	\$ 27,142	\$ 5,477	\$ 7,675	\$ 350	\$ 40,644	\$ 15,478.09

<i>Kendall Model - 2 story</i>	Framing, Insulation & Air Sealing	Windows & Exterior Doors	HVAC	Lighting	TOTAL	Premium from Baseline
2006 IECC	\$ 16,886	\$ 3,660	\$ 6,922	\$ -	\$ 27,467	
2012 IECC - Fiber	\$ 17,215	\$ 4,928	\$ 6,775	\$ 100	\$ 29,018	\$ 1,550.24
2012 CI Dow Premium	\$ 21,086	\$ 4,928	\$ 6,775	\$ 100	\$ 32,889	\$ 5,421.55
Beyond 2012 IECC - Renewable Ready	\$ 28,789	\$ 5,828	\$ 8,075	\$ 350	\$ 43,042	\$ 15,574.57

<i>Preston Model - Ranch</i>	Framing, Insulation & Air Sealing	Windows & Exterior Doors	HVAC	Lighting	TOTAL	Premium from Baseline
2006 IECC	\$ 16,945	\$ 3,447	\$ 6,922	\$ -	\$ 27,314	
2012 IECC - Fiber	\$ 17,744	\$ 5,130	\$ 6,375	\$ 100	\$ 29,350	\$ 2,035.68
2012 CI Dow Premium	\$ 22,297	\$ 5,130	\$ 6,375	\$ 100	\$ 33,902	\$ 6,588.09
Beyond 2012 IECC - Renewable Ready	\$ 29,023	\$ 6,146	\$ 7,675	\$ 350	\$ 43,194	\$ 15,879.75

Cost Summary

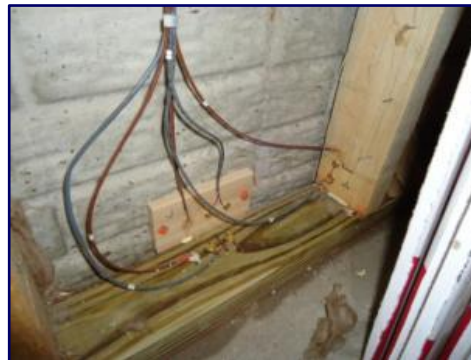
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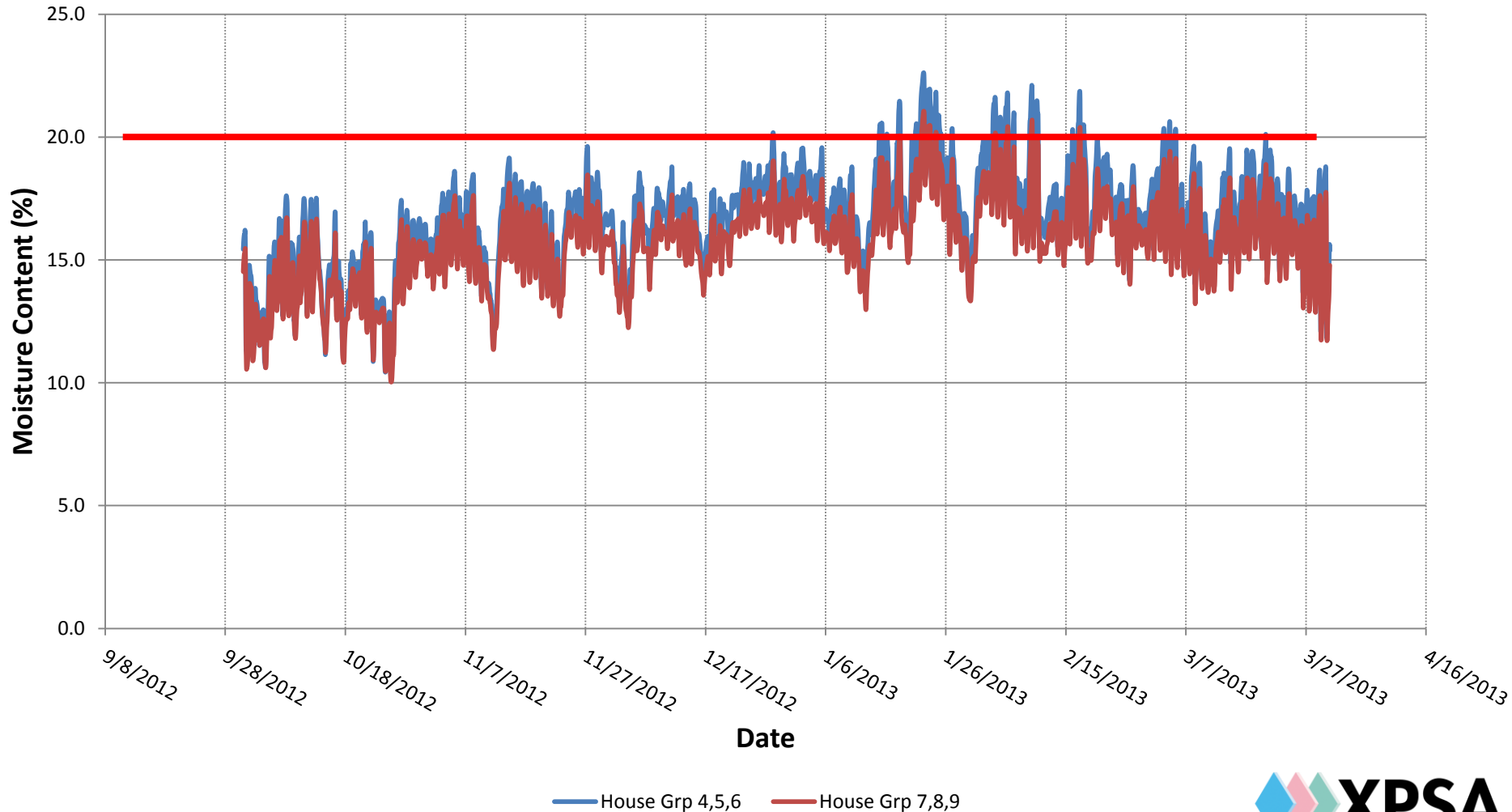
Hygrothermal Instrumentation & Data Acquisition

- ❑ Moisture Content, Temperature, RH
- ❑ Inside wall areas in each house
- ❑ Multiple measurements each measurement area
- ❑ Exterior temperature, RH

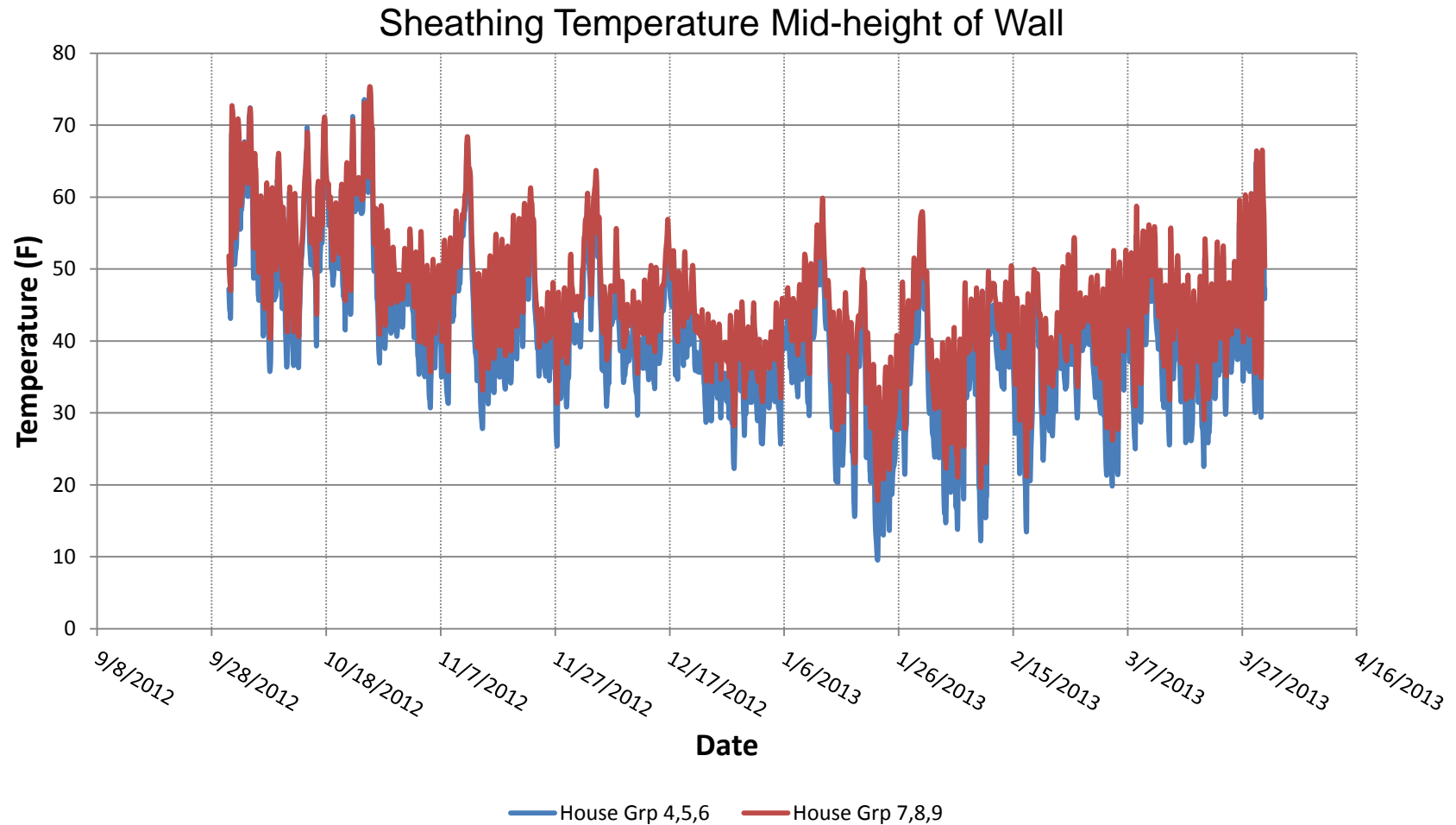


Hygrothermal Performance Above Grade Wall

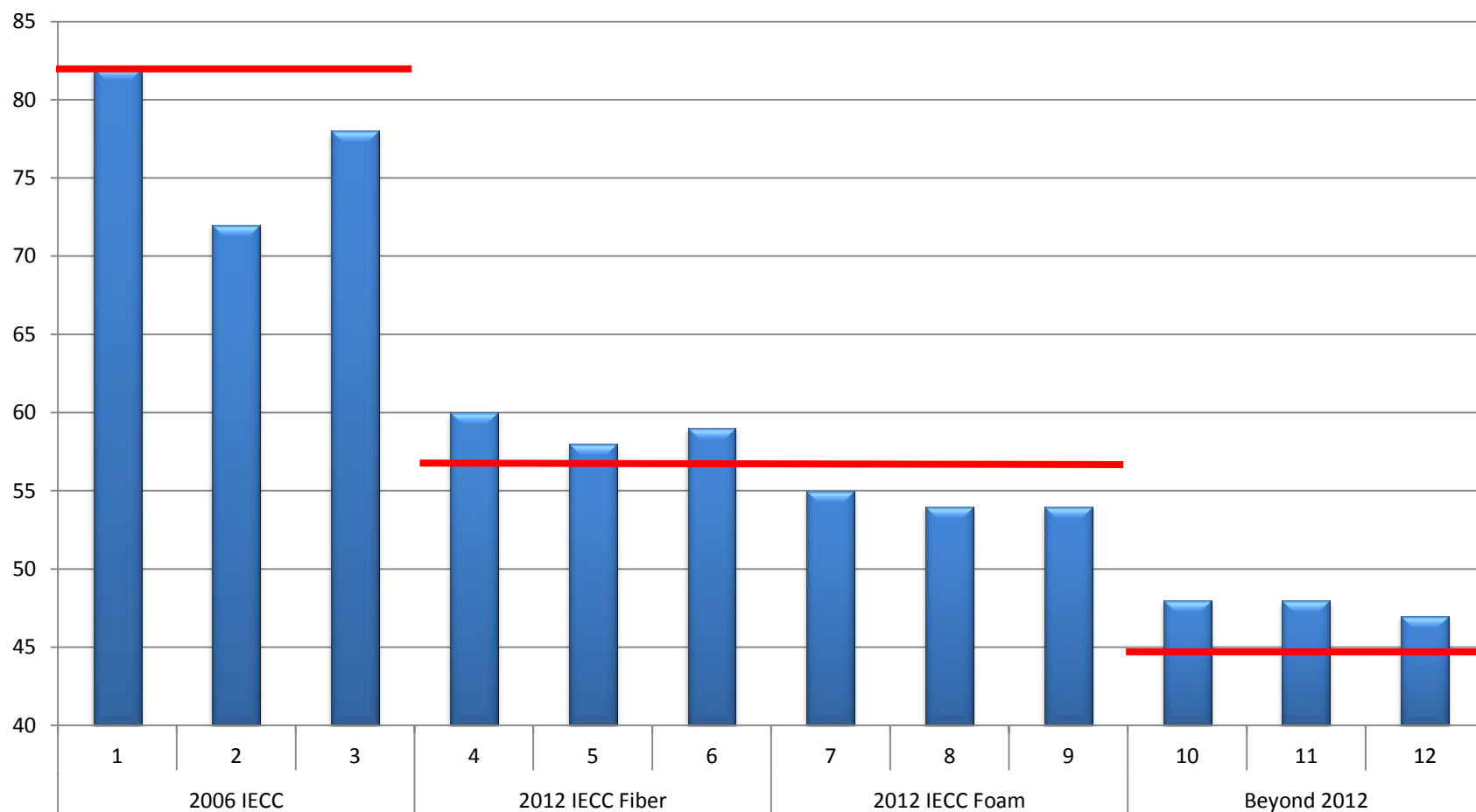
Sheathing Moisture Content Mid-height of Wall



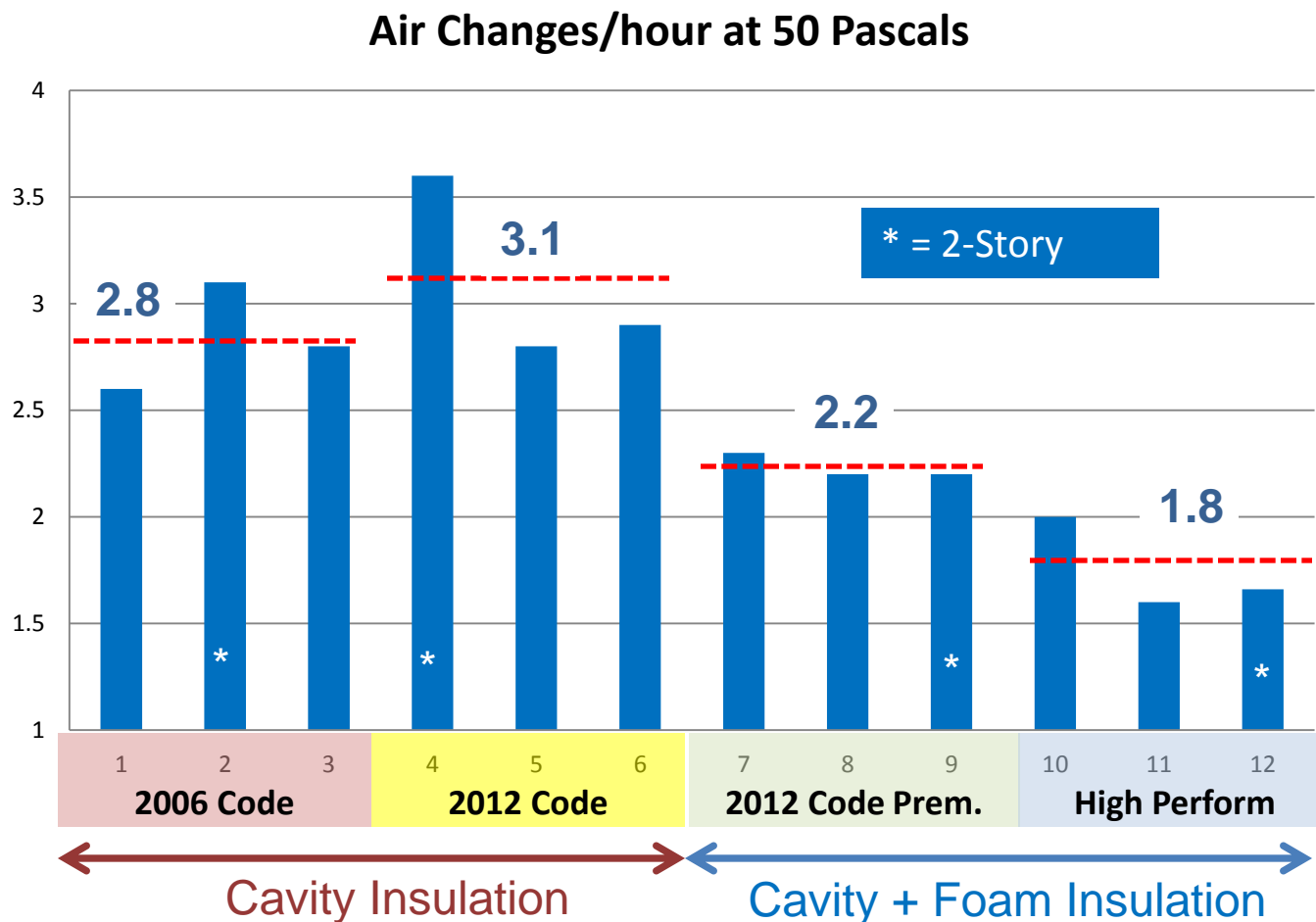
Hygrothermal Performance Above Grade Wall



Energy Target vs. Confirmed HERS Index



Comparison of Air Leakage



2012 IECC Without & With Continuous Insulation



OSB Plus Housewrap

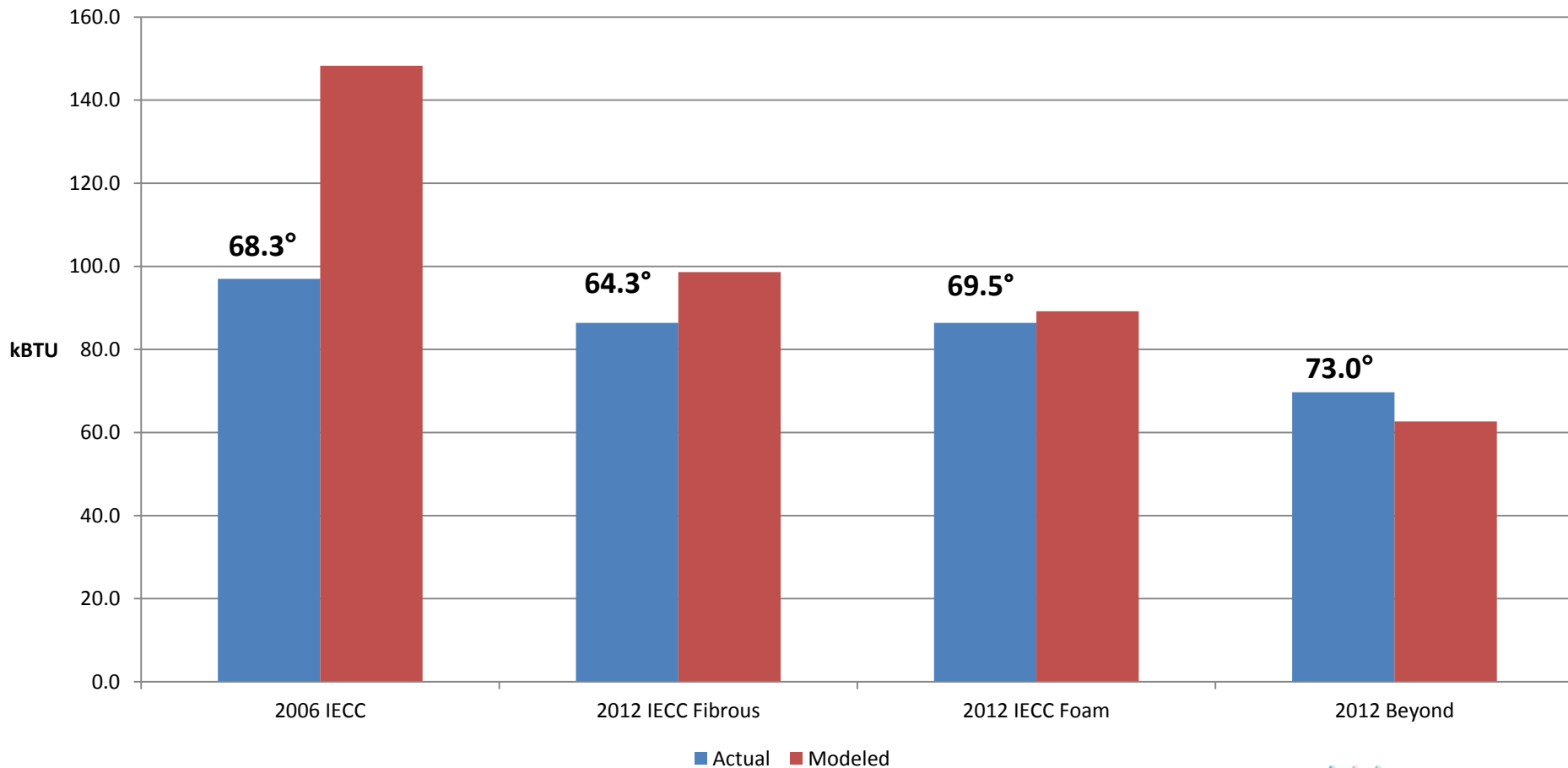


R-5 Continuous Insulation

Energy

Actual vs. Modeled Heating – Winter 2012-2013

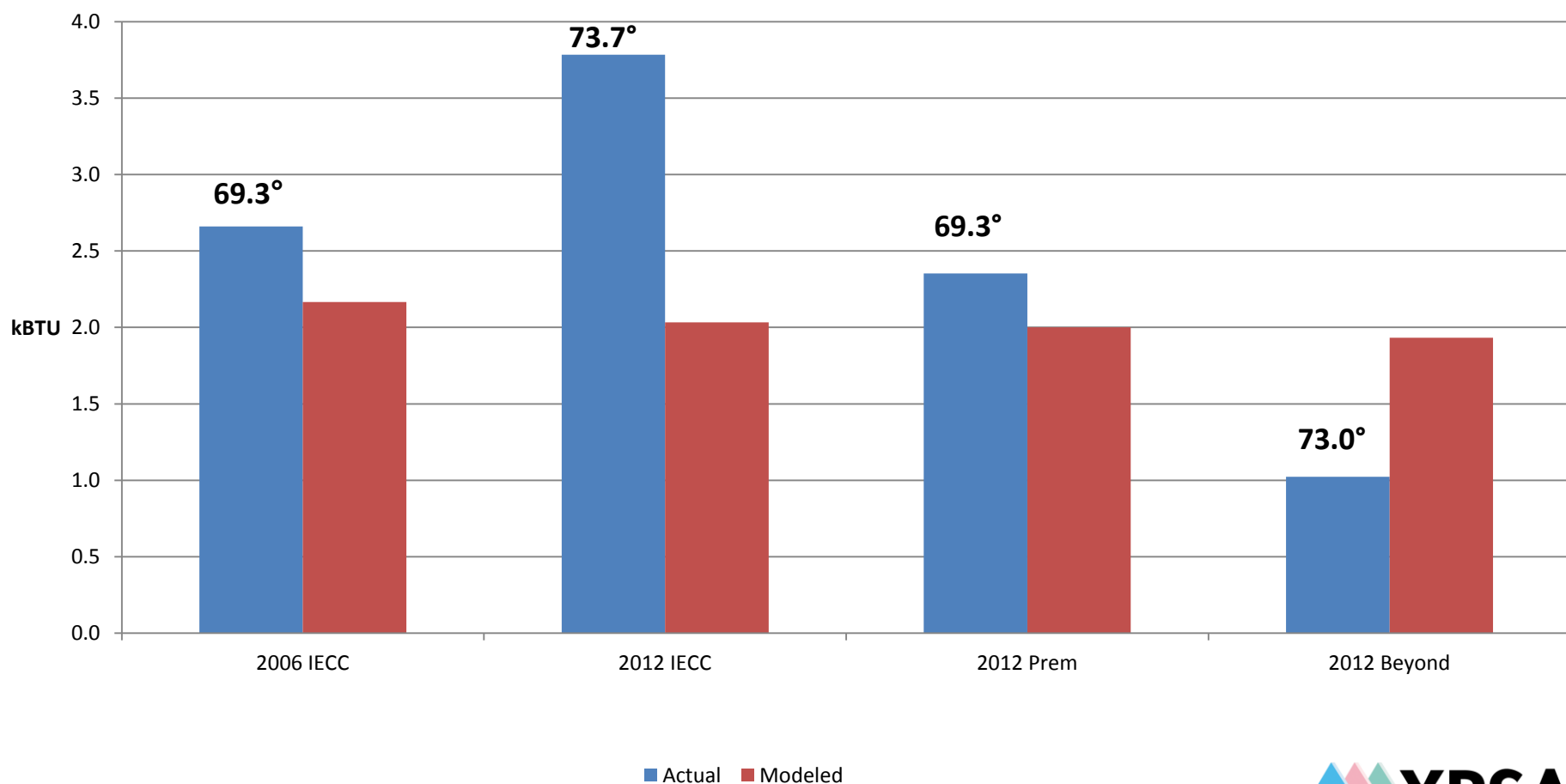
Total kBTU 10/2012 - 5/2013 per Build type



Energy

Actual vs. Modeled Cooling – Summer 2013

Average Cooling kBTU 5/2013 - 9/2013 per Build type (Occupied Homes Only)



Occupant Survey:





General Observations

Notes:

- Two surveys have been conducted to date
 - Occupants do not know the energy performance strategy of their home
-
- Nearly all say it is important to reduce the energy use in their homes
 - They closely follow their energy bills
 - They don't have a good understanding on the impact they have on the amount of energy they use
 - Some associate higher than expected energy bills to poor construction quality





Occupant Survey

How efficiently is the home performing energy-wise?

2006 IECC	2012 IECC - Cavity	2012 IECC – Cavity + Foam	Beyond 2012
 Less than pleased		 Neutral	





Occupant Survey

How satisfied are you with the level of warmth in your home when it is cold outside?

2006 IECC	2012 IECC – Cavity	2012 IECC – Cavity + Foam	Beyond 2012
		 Pleased	





Occupant Survey

How satisfied are you with the level of cooling in your home when it is hot outside?

2006 IECC	2012 IECC – Cavity	2012 IECC – Cavity + Foam	Beyond 2012
			





Occupant Survey

Does the temperature feel the same to you throughout all the rooms of your home?

2006 IECC	2012 IECC - Cavity	2012 IECC – Cavity + Foam	Beyond 2012
			

Occupant Survey

Does your home feel drafty?

2006 IECC	2012 IECC – Cavity	2012 IECC – Cavity + Foam	Beyond 2012
			

Next Steps

- Report Winter 2013-14 in May
- Compare % of H&C to total energy used
- Compare reported T-stat set point to actual temperature
- Focus group
 - \$ Comfort
 - \$ Durability
 - Share Actual Data

Summary & Conclusions

- Cost to build to 2012 IECC was lower than many estimates
- Foam strategies resulted in significant improvements in air leakage
- Actual energy used to heat was lower than model for three out of four strategies
- Exterior insulation above and below grade produced warmer and dryer assemblies
- Consumers are in need of better information on the energy efficiency features of their homes and the role they play in energy usage